IN SITU SURVEY OF GRAPHITE IN UNEQUILIBRATED CHONDRITES: MORPHOLOGIES, C, N, AND H ISOTOPES; S. Mostefaoui[1], E. Zinner[2], P. Hoppe[3], and A. El Goresy[1]; [1]Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany; [2]McDonnell Center for the Space Sciences and Physics Department, Washington University, St. Louis, MO 63130, USA; [3]Physikalisches Institut, Universität Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland.

We identified various graphite morphologies in situ in chondritic meteorites. Measurements of their C-, N-, and H-isotopic compositions with SIMS revealed large variations in $\delta^{15}N$ ratios in the various morphologies in the same chondrite. Graphites with very high enrichments in ^{15}N were encountered in Khohar ($\delta^{15}N$ up to 955‰). These graphites probably originated from interstellar molecular clouds. Also large enrichments in ^{15}N ($\delta^{15}N$ up to 438‰) were found in Acfer 182, 207, and 214. Systematic variations in $\delta^{13}C$ were also found among H, L, LL, CR, and CO chondrites.

Introduction: We have initiated detailed in situ microscopic studies of graphite morphologies and ion microprobe C- and N- isotopic analyses of various graphite types in chondritic meteorites with the aim to: **a**- search for correlations between morphologies and C- and N- isotopic compositions, **b**- characterize graphite of solar system origin in comparison to graphites with isotopic anomalies, and **c**- search for assemblages containing graphite of extrasolar system origin.

Isotopic heterogeneities of C and N in the graphite found in the differentiated Acapulco meteorite [1] indicate high isotopic retentivity of graphite at elevated temperature (1200ºC) [2]. These studies were extended to different chondrites, including Khohar, Inman (both L3-type), Grady (1937) (H3), Acfer 182, Acfer 207, and Acfer 214 (considered samples of one CR chondrite).

Petrography: In situ reflected light microscopy of the graphite showed: **a**- various graphite morphologies occur in each meteorite, **b**- graphite grain sizes vary over a large range (from <0.5 to ~15µm), and **c**- graphite occurs in a large variety of assemblages.

The encountered morphologies include graphite books, granular, cliftonite, and fine-grained aggregates. The first three have sizes ranging between 1 and 15µm. Graphite grains of the fine-grained type do not exceed ~ 0.5µm. This type usually fills the space between graphite books, and forms large graphite aggregates, which reach several hundreds of microns in Khohar and Grady. Graphite in Khohar and in Inman is present in metal. In some cases in Khohar it also occurs between silicates. Graphite in Acfer 182, Acfer 207, and Acfer 214 exists as small aggregates between silicates. Graphite in Grady is usually associated with troilite.

Isotopic compositions: C-isotopic ratios of the investigated graphites are close to normal (i.e. within the range found in terrestrial samples) and $\delta^{13}C_{PDB}$ values are mostly negative (Figures A and C). Nonetheless, within a given chondrite, significant variations in $\delta^{13}C$ are found (e.g. from -54 to -17‰ in Khohar). N-isotopic ratios in Inman and in Grady are also close to normal. However, much larger variations exist in Acfer 182, Acfer 207, Acfer 214, and especially in Khohar (Figure A). This meteorite has isotopically heavy N with $\delta^{15}N$ values reaching 955‰. This confirms the high ^{15}N enrichment of up to 1135‰ previously found in Khohar graphite [3]. In addition, Figures A and B indicate the presence of at least four distinct graphite populations in Khohar. Populations II, III, and IV have $\delta^{15}N$ >300‰, far from population I in which all $\delta^{15}N$ values are close to zero. Also, the highest $\delta^{15}N$ values in Khohar occur in N-poor graphites (see Figure B). In general, the intimate intergrowth between books and fine-grained graphites in Khohar made it impossible to analyze each type separately, and thus to inspect if there is any correlation between the graphite morphologies and the encountered isotopic populations. However, analyses of large isolated books and a vein in the metal filled with only fine graphites show normal N-isotopic compositions and isotopically heavy N, respectively. The heavy N components in Khohar appear thus to be sited in the N-poor fine-grained graphites.

Excesses in ^{15}N were also found in Acfer 182, Acfer 207, and Acfer 214, with a maximum $\delta^{15}N$ value of 438‰ in Acfer 182 (Figure C). Graphite in Acfer 182 is possibly related to the carrier of heavy N found in residues by Grady et al. [4] in the same meteorite, but the ^{15}N excesses found in this study fall short of the excesses measured in the residues. D/H measurements in Khohar graphite gave only a maximum D enrichment of 350‰. Contamination with water of normal isotopic composition during the polishing process could have resulted in decreased δD values.

Discussion: In spite of the significant C-isotopic variations in graphites from a given chondrite, ranges of $\delta^{13}C$ are comparable for chondrites of the same petrologic type. In Figure D we plotted $\delta^{13}C$ for different chondrite types, together with the results obtained earlier for Bishunpur and Kainsaz [6]. For comparison, we also plotted $\delta^{13}C$ for graphite from Acapulco [1,6]. The $\delta^{13}C$ values decrease from CO3 to CR, H3, and L3, with an intermediate range for Acapulco between the (H, L) and the CR types. The data show that C-isotopic heterogeneities occur not only on a small scale (in meteorites of the same petrologic type), but also on a larger scale within the early solar system (i.e. different chondrite classes).

The observed $\delta^{15}N$ values in the graphite from Khohar and Acfer 182 range up to levels that can not be explained by fractionation processes occuring within the solar system and thus indicate an interstellar origin. Novae are known to produce large amounts of ^{15}N, but heavy N from such a source is predicted to be accompanied by heavy C [5], which is not the case in Khohar and in Acfer 182. Zinner et al. [8], and Messenger et al. [9] have interpreted ^{15}N

enrichments found together with isotopicaly normal C in some graphite grains from Murchison and IDPs as the result of isotopic fractionation processes occurring at low temperatures in interstellar molecular clouds (IMCs) material. This is a possible explanation for the ^{15}N-excesses in Khohar graphite, but additional results are needed to make this interpretation more conclusive.

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